Birdie: Towards a true flying experience

Benjamin Petry[1]
benjamin_petry@mymail.sutd.edu.sg

Shaohui Foong[2]
foongshaohui@sutd.edu.sg

Santiago Ortega-Avila[1]
santiago@sutd.edu.sg

Suranga Nanayakkara[1]
suranga@sutd.edu.sg

[1] Augmented Senses Group
[2] Magneto-Mechatronics Lab
Singapore University of Technology and Design
20 Dover Drive
Singapore 138682

AA 2014, April 27, 2014, Toronto, Canada.

Abstract
In this paper, we present Birdie, a novel sensory experience as a first step towards a true flying experience. With the use of a tele-existence concept [6, 2] an augmented human controls an unmanned aerial vehicle (UAV) remotely. At the same time he or she receives multi sensory feedback like vision and sound from the UAV. We also introduce intuitive interactions, as well a possible implementation of Birdie.

Author Keywords
Augmented Human, Flying Experience, Interaction Design, Tele-Existence

ACM Classification Keywords
H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities.

Introduction
The dream of flying is as old as humanity itself. Over several centuries, people attempted different ways and invented artefacts to fulfil this dream [1]. The use of wings were among the first unsuccessful tries. Nowadays, thanks to the growing knowledge in aerodynamics, helicopters and aircraft are the most common ways to fly. However, these vehicles are unable to provide us with a true flying experience because their walls act as a barrier

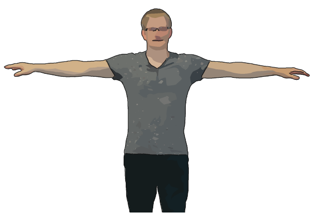

Figure 1: Basic flying position

Figure 2: Control the altitude with tiptoeing or squatting

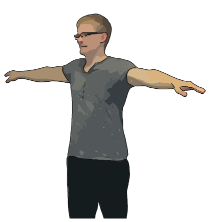

Figure 3: Self-rotation

against our innate senses. Flight simulators [4] are another approach to experience flying, but they restrict the user's exploration to virtual worlds. To overcome this limitation, Flying Head [3] introduces a tele-presence system, where a human, wearing a head mounted display for visual feedback, controls an unmanned aerial vehicle (UAV) by walking, jumping and crouching. This system however, provides users with a 'walking in air' rather than a flying experience. Only extreme sports like paragliding or skydiving let us be close to the feeling of flying, but these are dangerous and not suitable for most people. The above examples have their own limitations and are unable to provide the same experience that e.g. birds would feel. We seek to overcome these limitations by augmenting a human through sensory extension and synaesthesia. In this paper, we present *Birdie*, a novel sensory experience as an initial step towards this broader vision of a true flying experience.

What does it mean to feel like a bird? Birds are able to feel the wind and warmness. They see, hear and smell all the things around them. As such, flying should be an intuitive and multi sensory experience. Moreover, it gives them the freedom to go wherever they want and to explore whatever they want. In addition, birds are able to hunt prey and carry objects with their feet to different locations. We believe that three important aspects of a true flying experience are (1) to get a multi sensory experience, (2) to have an intuitive way of flight control and (3) to be able to transport objects.

Birdie follows the concept of a tele-existence system [6, 2], which consists of a master and slave. In this case, the slave is an unmanned aerial vehicle (UAV). It has different sensors to collect sensory information, as well as a robotic arm to perform a transportation task. The UAV is remotely controlled by the master, which in this case is an augmented human (the user). Movements of the user are tracked and sent to the UAV, which interacts in the real world and sends the sensory feedback such as vision and sound back. This makes the user to feel as if he or she is the UAV itself.

Application Scenarios

Birdie offers a lot of new possibilities. In this section we introduce different scenarios where Birdie could bring an advantage.

Recreational Exploration

Birdie can provide a broader experience when travelling and visiting new places such as the Red Canyon in Utah. It gives people the freedom to visit caves or hear birds flying around. Usually most of the people see such places only from the ground, so their experience is limited. Observation wheels or helicopters, for example, can be used to bridge this gap, but they still limit the users' freedom. With Birdie, points of interest will become more explorable. Furthermore, Birdie would be suitable for untrained visitors to get a full experience of such places. In the future, this could be a recreational system that people own and use from home.

Military

Drones are used to explore areas by the military. The main challenge is to control the video camera. Usually for this task a remote control is used, which is not intuitive. With Birdie, a user can explore an area in a natural manner. Furthermore, the user is able to look at objects by moving his or her head, and grabbing them as if he or she was using his or her own hands. This is advantageous in critical situations where intuitive interactions can potentially result in faster and more precise operations.

Figure 4: Bringing the arms together enables fast speed

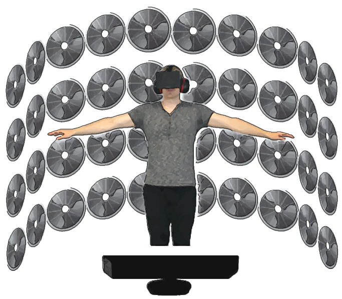

Figure 5: Simulation box

Interacting with Birdie

In this section, we describe Birdie's interactions and their mapping to the UAV control to create a seamless experience. These interactions are presented in three subsections:

Multi Sensory Experience Interactions
Birds move their head to focus on things they see or hear. While they are moving their head, the field of vision and sound changes. Ideally, a user should be able to experience these same sensations in a natural manner. If the user is moving his or her head he or she should get the feeling as if he or she is the UAV itself. So the field of vision and sound has to be adjusted related to the user's head movement.

Flight Control Interactions
Four parameters have to be controlled to fly a UAV:

- pitch (results in forward/backward movement)
- roll (results in left/right movement)
- altitude
- yaw (the self-rotation)

To translate these flight controls into a more bird-like and intuitive movement, these parameters could be mapped to the upper body's movement of the user (based on [5]). The basic flying position is shown in Figure 1. To control the forward, backward, left and right movement the user has to lean to the corresponding direction. With tiptoeing and squatting (Figure 2) the user can control the altitude. Furthermore, the upper body's self-rotation (Figure 3) is used to control the yaw. These interactions can be combined seamlessly to enable intuitive control of the UAV.

The flight speed depends on two parameters: (1) how much the user lean, tiptoe or squat (*precise speed*) and (2) the nearness of the user's spread-eagled arms (*fast speed*). Moving the arms together as shown in Figure 4 will increase the speed, while moving them apart will decrease it.

A further aid to support users flying long distances is the hold-mechanism. This mechanism could save the user's last position and will take over the control of the UAV. This avoids the user getting tired holding a certain position. The mechanism is activated by raising one hand up. Going back to the flying position as shown in Figure 1, will deactivate the mechanism and will give the control back to the user.

Transportation Interactions
To enable transportation one arm must be attached to the body, while the movements of the other one are mapped to the robotic arm [2]. Grabbing is usually a precise task that doesn't need fast speed. Therefore the fast speed interaction is not available when using the robotic arm to avoid interference.

Implementation

The envisioned implementation of Birdie consists of two parts: (1) the flying system (Figure 6) and (2) the simulation box (Figure 5).

The flying system could comprise of a quadcopter (UAV lifted and propelled by four rotors). It could be augmented with five microphones (left-front, left-back, right-front, right-back and center) to record surround sound and a stereoscopic camera with a robotic pan and tilt system to record images for the user's vision. Furthermore, a robotic arm[1] for grabbing and transportation could be mounted to

[1] `http://goo.gl/B7HQ1O`

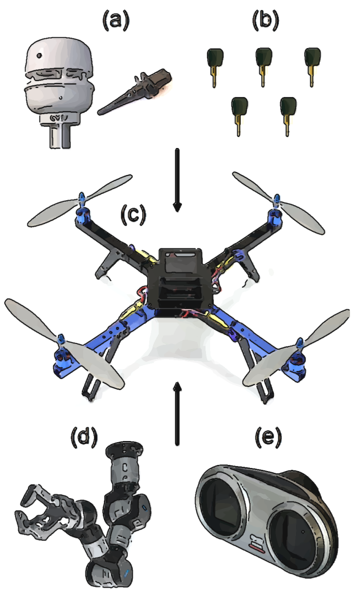

Figure 6: Flying system:
(a) Anemometer & Temperature Sensor, (b) Microphones,
(c) Quadcopter, (d) Robotic Arm, (e) Stereoscopic Camera

the quadcopter as well an anemometer and a temperature sensor to get the wind's speed and temperature.

The simulation box is the space where the user experiences 'Flying like a bird'. It could consists of a room equipped with Kinect[2] technology to track the user's motions. The user stands in the middle of the room wearing the Oculus Rift Headset[3] for visual feedback, and a pair of surround sound headset for auditory feedback. For the wind and temperature feedback, fans with a cooler and heater system could be placed around the user[4,5].

Discussion

Birdie opens up new possibilities as described in the application section, but at the same time it raises many questions and limitations.

Implementation of Birdie poses many challenges such as accurate gesture tracking and the mapping of users action into feedback. It has to be evaluated if the proposed factors (multi sensory feedback, intuitive flight control and transportation of objects) are sufficient enough to provide an 'in the quadcopter' experience. Previous work [7] have shown that prolong exposure to augmented reality might cause nausea. As such, user-centred iterative implementation process would help identify and mitigate those effects. In addition, a collaborative system consisting of multiple Birdies would open up a new space for investigation of tele-existence behaviour among multiple users.

Despite the limitations, we believe that Birdie could be a first step towards providing a new perspective of the world.

[2] `http://www.xbox.com/en-US/kinect`
[3] `http://www.oculusvr.com/`
[4] `http://www.youtube.com/watch?v=EEA1BCKDIsM`
[5] `http://www.youtube.com/watch?v=C6Q2RsT_MHQ`

Acknowledgements

This work is partially funded by the SUTD President's Graduate Fellowship and the International Design Centre (IDC) at SUTD.

References

[1] Anderson, J. D. *A History of Aerodynamics: And Its Impact on Flying Machines*, vol. 8. Cambridge University Press, 1998.

[2] Fernando, C. L., Furukawa, M., Kurogi, T., Hirota, K., Kamuro, S., Sato, K., Minamizawa, K., and Tachi, S. Telesar v: Telexistence surrogate anthropomorphic robot. In *ACM SIGGRAPH 2012 Emerging Technologies*, SIGGRAPH '12, ACM (New York, NY, USA, 2012), 23:1–23:1.

[3] Higuchi, K., and Rekimoto, J. Flying head: A head motion synchronization mechanism for unmanned aerial vehicle control. In *CHI '13 Extended Abstracts on Human Factors in Computing Systems*, CHI EA '13, ACM (New York, NY, USA, 2013), 2029–2038.

[4] Page, R. L. Brief history of flight simulation. *SimTecT 2000 Proceedings* (2000), 11–17.

[5] Sanna, A., Lamberti, F., Paravati, G., and Manuri, F. A kinect-based natural interface for quadrotor control. *Entertainment Computing 4*, 3 (2013), 179 – 186.

[6] Tachi, S., Arai, H., and Maeda, T. Tele-existence master-slave system for remote manipulation. ii. In *Decision and Control, 1990., Proceedings of the 29th IEEE Conference on* (1990), 85–90 vol.1.

[7] von Kapri, A., Rick, T., and Feiner, S. Comparing steering-based travel techniques for search tasks in a cave. In *Virtual Reality Conference (VR), 2011 IEEE* (March 2011), 91–94.